SECTION

III

Future Conditions and Directions

Preface

Sections I and II have described water resource conditions within the Santa Cruz Active Management Area (AMA) and the regulatory programs designed to cause efficient use of water and promote the utilization of effluent and other alternative water supplies. The Arizona Department of Water Resources' (Department) regulatory program for the third management period, described in Section II, represents the first management strategy specific to the Santa Cruz AMA and its management goals of maintaining safe-yield and preventing long-term declines in local water table levels.

Section III describes projected future conditions within the Santa Cruz AMA, as well as the directions the Department proposes to take in developing additional water management programs during the third management period.

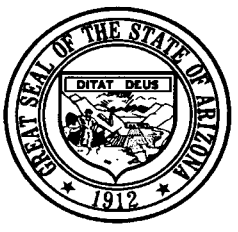
Potential future water supply and demand conditions are described in Chapter 11. The Department's review of supply and demand conditions is designed to illustrate a range of supply and demand possibilities for consideration as we develop our management programs.

Chapter 12 describes some options for the future looking toward exploration of potential sources of supply, examining augmentation strategies, limiting impacts of new wells, and requiring efficient use of water to help maintain the AMA goals into the future. Chapter 12 summarizes existing water management problems, identifies the obstacles to maintaining safe-yield and local water table levels, and describes the actions that the Department, AMA water providers, and water users can take during the third management period and beyond.

CHAPTER

11

Water Supply and Demand Analysis



11.1 INTRODUCTION

The Arizona Department of Water Resources (Department) uses detailed, AMA-wide water budgets as a tool to determine the balance between water demands and supplies. Water budgets are one method of estimating the current and projected status of an Active Management Area (AMA) relative to the management goal of safe-yield. Because these budgets address conditions on an AMA-wide scale, they are not useful in determining the long-term effect of pumping and recharge on local water table levels. Continued monitoring of local water levels and the further development of the hydrologic model of the Santa Cruz AMA will provide information useful in developing management strategies for local water tables. This chapter discusses the safe-yield portion of the Santa Cruz AMA goal.

Long-term averages of natural recharge to the aquifer from precipitation and surface flow are usually incorporated into AMA-wide water budgets. These figures are useful in AMAs with sufficient groundwater storage that is not significantly affected by variations in surface water flow. They are also useful in instances where timely data is not collected and where measurements are not made. However, due to the extreme variability in precipitation and surface flow in the Santa Cruz AMA, net natural recharge in the AMA varies not only from year to year but from season to season. See Chapter 2. Water budgets that use long-term averages for natural supply components do not illustrate the seasonality and variability in some components of net natural recharge, which is an important factor to consider in water management in the Santa Cruz AMA. Therefore, the use of long-term averages, in some instances, is insufficient as a water management tool for the Santa Cruz AMA.

The Santa Cruz AMA is particularly susceptible to drought conditions since a firm backup or alternative supply to water withdrawn from wells in the Younger Alluvium is not readily available. In years where there is low rainfall and little surface flow along the Santa Cruz River, water in storage is depleted. In order to prepare for periods of drought, augmentation of the water supply combined with improved distribution and efficient use of current supplies will be needed as municipal and industrial water demand continues to increase. A number of factors can affect the development and implementation of augmentation projects. These are described in detail in Chapter 8. When demands increase to the point where supplies are fully utilized, augmentation will be needed to meet the demands of additional growth even during non-drought periods in order to maintain safe-yield conditions.

Two methods of projecting water demand are included in this chapter. The Current Use Rate Scenario uses the average demand for the three water use sectors from 1992-1995 to project demand. The Increased Efficiency Scenario projects municipal water demand based on an increased level of efficiency. These scenarios provide a general idea of the increase in water demand that might occur by 2025, and the reduction in demand that could be realized if large municipal water providers implement conservation measures.

Water is a physical resource and as such can be tracked and understood in physical terms. However, water management has historically been tied to legal accounting mechanisms for water rather than based exclusively on the hydrology. Legal mechanisms for water accounting address issues such as internationally shared effluent, adjudication of surface water rights, and encouraging the use of remediated groundwater. However, these inconsistencies between physical reality and legal accounting complicate discussion of water supplies.

In the Santa Cruz AMA, effluent discharged from the Nogales International Wastewater Treatment Plant (NIWWTP) is not delivered through a distribution system for direct use. The effluent, surface water, and groundwater are commingled in the Younger Alluvium along a reach of the Santa Cruz River downstream from the NIWWTP. Because NIWWTP effluent discharge stabilizes water tables in the Younger Alluvium and contributes to the AMA's safe-yield balance, it is important to include it as a water supply in an evaluation of supplies versus demands.

11.2 HISTORIC DEMANDS

Chapter 3 of this plan provides information on historic demand in the municipal, industrial, and agricultural demand sectors from 1985 through 1997. Demand components for these sectors are based on water withdrawals and use reported to the Department. Although limited information is available on exempt well pumpage, it is included in these budgets as an estimate for stock watering and domestic exempt uses, based on the number of registrations on file. The Department has no monitoring and reporting authority over water withdrawals from exempt wells. Other demand components included are underflow exiting the AMA and riparian demand.

11.3 PROJECTED DEMANDS

Two projected demand scenarios have been developed by the Department to analyze possible future water demand and supply conditions in the Santa Cruz AMA. The projected demand scenarios are as follows:

- **Current Use Rate:** Assumes that recent average municipal, agricultural, and industrial water use practices continue through the year 2025. The total demands as calculated in this scenario are shown in Table 11-1.

- **Increased Efficiency:** Assumes that municipal demand levels are reduced to meet Third Management Plan conservation requirements by 2010 and these reduced rates continue through the year 2025. The total demands as calculated in this scenario are shown in Table 11-2.

The following general assumptions stay constant for both water budget scenarios:

- The AMA population projections are based on Arizona Department of Economic Security (ADES) projections published in 1997.

- The natural system demand estimates are derived from Table 3-9. Although water demand associated with riparian areas (phreatophytes) could increase after a series of wet years and could be reduced as riparian areas are lost in some areas during dry periods, riparian demand estimates are held constant for each projected year in both budgets due to the difficulty in projecting riparian demand increases or decreases under wet or dry conditions. Subflow leaving the AMA is also held constant. Although this estimate may vary from year to year and season to season, the variation may not be significant. Additional development of the Department's hydrologic model may result in an adjustment to the figure used for subflow out of the AMA.

- Exempt well demand is estimated based on the assumption that each registered well withdraws 0.5 acre-feet per year. Exempt wells used for domestic purposes are projected to increase at the 1994-1998 average rate of 32 new well registrations per year. Exempt wells used for stock watering are projected to increase at the 1994-1998 average rate of four new well registrations per year.

- Active agricultural acreage in the Santa Cruz AMA is reduced by 1,000 acre-feet to account for the sever and transfer of a portion of the water rights associated with Rio Rico Properties. No further declines in agricultural demand are projected.

- Industrial water use projections are proportional to the population growth rate projected for the Santa Cruz AMA.

Specific demand assumptions for each sector are described in the following sections.

11.3.1 Agricultural Demand Assumptions

Total agricultural water demand was 8,960 acre-feet in 1985; 11,603 acre-feet in 1990; and 12,884 acre-feet in 1995. Water use between 1990 and 1996 ranged from a low of 8,122 acre-feet in 1993 to a high of 15,913 acre-feet in 1994, although the pattern reflects numerous fluctuations instead of a consistent rise in water use, as shown in Figure 3-2. Water use by the largest agricultural user, Rio Rico Properties, influences the trend in agricultural use.

Agricultural water demand is a function of the total acreage which can legally be irrigated, the land actually cultivated in a given year (the crop-acreage ratio), the efficiency of water use, the average consumptive use of crops, and any lost and unaccounted for water. There are agricultural lands within the Santa Cruz AMA which have both an Irrigation Grandfathered Right (IGFR), regulated under the Groundwater Code, and a surface water right claim, subject to adjudication under surface water law. This situation is referred to as a "dual right" because the IGFR and surface water claim pertain to the same acreage. Under surface water law, agricultural uses of surface water that are discontinued for a period of time are susceptible to forfeiture or abandonment. In order to avoid the possibility of losing their claims to surface water, high volumes of water are sometimes used. These high use years may not coincide with economic factors which favor higher agricultural production or years of low precipitation. More information on agricultural water use characteristics and projections is contained in chapters 3 and 4.

The Department has not collected information on irrigated acres on a regular basis in the Santa Cruz AMA. There are about 5,300 acres of farmland within the AMA that have an IGFR. In 1994, the Department conducted a survey of farms which revealed that roughly 2,100 acres of this total irrigable acreage were cultivated in the AMA that year. Most of this farmland is anticipated to remain active throughout the third management period and afterwards. The surface water rights claim associated with about 200 acres of IGFR farmland, amounting to about 1,000 acre-feet of water demand, were severed and transferred by Rio Rico Properties in 1996 to support municipal growth.

The 1992-1995 average water use by the agricultural sector was 11,300 acre-feet. Agricultural demand was reduced to 10,300 acre-feet in the year 1997, which first appears in the projected year 2000. This reflects the Rio Rico sever and transfer. While some individual right holders may convert their rights to support residential growth, projected agricultural demand is not reduced below 10,300 acre-feet. However, discontinuing demand in one sector in order to increase demand in another sector is one tool that can be used to help maintain safe-yield conditions.

11.3.2 Municipal Demand Assumptions

Municipal demand includes potable and nonpotable water use by AMA water providers. Nonpotable water is delivered through a distribution system distinct from the potable distribution system, usually for the purposes of landscape or turf-related watering. Water demand associated with exempt domestic wells is estimated due to the lack of information on actual demand. Population and per capita water consumption are the primary factors that influence municipal demand.

11.3.2.1 Population

Executive Order 95-10 requires state agencies to utilize the population projections approved by the ADES. The ADES prepares population projections for the state every five years. These projections are disaggregated by the counties for local jurisdictions. The Department further disaggregates the ADES projections into subbasin and AMA boundaries statewide. Because projections must be consistent with the state total, many communities in the state are assigned lower projections than the growth that the local community actually expects will occur. For the last several years, the ADES projections have proven low compared to observed growth. This will probably be the case with the ADES projections used by the

Department in this chapter, which were prepared in 1997. Observed growth may be considerably higher than the population projections used in the water budgets contained in this chapter.

Based on the information collected by the Department in Annual Water Withdrawal and Use reports, it appears that recent growth rates in the Santa Cruz AMA are exceeding the rates of growth used by ADES in 1997 to calculate projections. Since the population projections are only updated once every five years, changes in rates of growth within the five-year time span may render the projections out of date. Moreover, differences in the projection methodologies used for the state, county, and local level may result in over or underestimation of the population for AMAs. For example, if the population projection for a city or town is high, but the projection for unincorporated areas of the county is low, then the total projection for the AMA may be low. The projections for municipal providers in unincorporated areas may also be low. In order to ensure the most accurate projections possible, building completions and certificates of occupancy in all areas within the AMA must be closely tracked and good records must be maintained since this is the main source of data used by ADES to develop population projections for the state. Appendices 11A and 11B show how population projections were disaggregated by the Department for water providers in the Santa Cruz AMA.

If the population grows at a higher rate than is indicated in the projections, the water demand will be higher. Also, if per capita water use is greater than the rate used in the projections, demand will be higher. The opposite is true if the population grows at a slower rate than projected and if demand is lower than anticipated. These figures provide an estimate of demand at current and more conserving use rates, using the official population projections as prepared by ADES, in order to develop future demand scenarios for planning purposes. As new projections are developed and approved, these projections will change.

11.3.2.2 Water Use

The same set of population projections was used to calculate demand projections in each scenario. For more detail on municipal water use trends and Third Management Plan conservation requirements, please refer to chapters 3 (Water Use Characteristics and Trends) and 5 (Municipal Conservation Program).

11.3.2.2.1 Current Use Rate Scenario

The 1992 through 1995 average gallons per capita per day (GPCD) rates for large providers and for small providers as a whole were used to project demand for the current scenario. Note that these projections do not assume any additional water savings achieved through the implementation of water conservation measures or the use of low water use plumbing fixtures such as showerheads, faucets, and low-flow toilets. However, federal and state laws require the installation of low water using plumbing fixtures in new homes. Because low flow plumbing fixtures are now required, water demand in new homes should be lower, on a per capita basis, than water demand in existing homes.

11.3.2.2.2 Increased Efficiency Scenario

In the increased efficiency or conservation scenario, large municipal providers are assumed to take the steps necessary to maintain the existing residential GPCD requirements through the year 2025. In addition, all new residential growth after the year 2000 is assumed to use water efficiently, consistent with the models for new interior and exterior residential water use described in Chapter 5. The non-residential GPCD of each municipal provider is assumed to remain at the non-residential GPCD component requirement listed in Appendix 5D of this plan. Lost and unaccounted for water is held at the 1992-1995 average rate for each large municipal provider but is assumed not to exceed the 10 percent maximum for distribution system efficiency contained in the management plan. As in the base scenario, the 1992-1995 average GPCD rate was used to project small provider water demand through the year 2025 with no reduction.

11.3.3 Industrial Demand Assumptions

Industrial demand includes all water withdrawn pursuant to non-irrigation grandfathered rights and groundwater withdrawal permits. More information on industrial water use characteristics, trends, and specific conservation requirements for each industrial subsector is contained in chapters 3 and 6. The ratio of total industrial demand to population was calculated for the sum of demand and population for 1992 through 1995. This ratio was multiplied by the population projections for the AMA to project industrial demand. The same methodology for calculating industrial demand is used in each projected demand scenario.

11.3.4 Riparian Demand

Phreatophyte evapotranspiration associated with the riparian habitat is the largest water demand in the Santa Cruz AMA. Based on the methodology described in Chapter 3, it was estimated that the volume of riparian evapotranspiration losses is about 25,800 acre-feet per year. This estimate includes riparian areas along the Santa Cruz River in Nogales Wash and along Sonoita Creek and Sopori Wash.

The volume of phreatophyte evapotranspiration is held constant in the water budgets in this chapter. While the Department acknowledges that this volume is subject to change with years of maximum or minimum supply, there is limited data available to project phreatophyte consumption.

TABLE 11-1
CURRENT USE RATE DEMAND SCENARIO
SANTA CRUZ ACTIVE MANAGEMENT AREA (Acre-Feet)

	92-95 Avg.	2000	2005	2010	2015	2020	2025
Municipal Demand	6,300	7,300	8,100	8,800	9,700	10,500	11,400
Agricultural Demand	11,300	10,300	10,300	10,300	10,300	10,300	10,300
Industrial Demand	1,300	1,500	1,700	1,800	2,000	2,200	2,400
Exempt Well Demand	500	500	600	700	800	900	1,000
Riparian Demand	25,800	25,800	25,800	25,800	25,800	25,800	25,800
Underflow Leaving AMA[1]	8,700	8,700	8,700	8,700	8,700	8,700	8,700
Total Demand	**53,900**	**54,100**	**55,200**	**56,100**	**57,300**	**58,400**	**59,600**

[1] 8,700 is used in the Department's hydrologic model. In low supply years, this may be a little less, and in high supply years it might be a little more. This figure may be adjusted as development of the hydrologic model continues.

11.3.5 AMA Outflow

Estimated underflow exiting the Santa Cruz AMA into the Tucson AMA is about 8,700 acre-feet per year. See Chapter 3. Underflow, like the other natural system components included in the Santa Cruz AMA budgets, is subject to seasonal and annual fluctuations. In addition, increased demand associated with future development may have an effect on the volume of underflow leaving the AMA.

TABLE 11-2
CONSERVATION DEMAND SCENARIO
SANTA CRUZ ACTIVE MANAGEMENT AREA (Acre-Feet)

	92-95 Avg.	2000	2005	2010	2015	2020	2025
Municipal Demand	6,300	7,000	7,600	8,200	8,900	9,600	10,300
Agricultural Demand	11,300	10,300	10,300	10,300	10,300	10,300	10,300
Industrial Demand	1,300	1,500	1,700	1,800	2,000	2,200	2,400
Exempt Well Demand	500	500	600	700	800	900	1,000
Riparian Demand	25,800	25,800	25,800	25,800	25,800	25,800	25,800
Underflow Leaving AMA[1]	8,700	8,700	8,700	8,700	8,700	8,700	8,700
Total Demand	**53,900**	**53,800**	**54,700**	**55,500**	**56,500**	**57,500**	**58,500**

[1] 8,700 is used in the Department's hydrologic model. In low supply years, this may be a little less, and in high supply years it might be a little more. This figure may be adjusted as development of the hydrologic model continues.

11.4 SUPPLY RANGES

11.4.1 Net Natural Recharge

Natural recharge components include: (1) main channel natural flow and (2) mountain front and tributary natural recharge. An estimated range for each of these components is presented in Table 2-2. Chapter 2 also contains information on the data sources for these ranges. The range in estimates of main channel natural flow are between 1,300 acre-feet and 88,600 acre-feet per year. The range in estimates for major tributary recharge is between 5,200 and 41,300 acre-feet per year. For the analysis included in this chapter, the 10th and 90th percentiles in the range of main channel natural flow and major tributary recharge were selected from a frequency analysis. Ninety percent of the time supplies greater than the minimum shown in Table 11-3 will occur. However, this also means that in about one year out of every 10 minimum supply conditions may be realized. Maximum supply conditions were also limited based on a percentile, where the maximum supply volume shown in Table 11-3 might only occur in one year out of every 10.

Mountain front and minor tributary recharge is estimated by Osterkamp to be about 11,400 acre-feet per year. This figure may be adjusted as work on the model continues.

11.4.2 Active Management Area Inflow

Water that flows beneath the land surface (underflow) enters the Santa Cruz AMA at the International Border at two general locations, along the Santa Cruz River and west of the City of Nogales. Underflow estimates range from about 100 acre-feet to 500 acre-feet per year along the Santa Cruz River and from about 120 acre-feet to 600 acre-feet annually west of the City from the Nogales Wash. In addition, inflow from Sonoita Creek is estimated at between 120 to 600 acre-feet per year. More details on these ranges are included in Chapter 2 of this plan. Consequently, total average underflow entering the Santa Cruz AMA ranges from about 340 to about 1,700 acre-feet per year.

TABLE 11-3
MAXIMUM AND MINIMUM WATER SUPPLY
SANTA CRUZ ACTIVE MANAGEMENT AREA
(Figures Rounded to Nearest 100 Acre-Feet)

COMPONENT	RANGE IN ACRE-FEET
INFLOWS	
RECHARGE	
Main Channel & Major Tributary Natural Flow (10th and 90th Percentiles)	8,400 - 106,300
Main Channel Effluent	15,600 - 19,900
Mountain Front and Minor Tributary	11,400
Incidental (Agricultural and Industrial)	3,900 - 3,600
Total Recharge	**39,000 - 141,500**
UNDERFLOW (estimated)	
Santa Cruz River at Mexico/US Border	100 - 500
West of Nogales Mexico/US Border	200 - 1,200
Total Underflow	**300 - 1,700**
TOTAL INFLOWS	**39,600 - 142,900**

11.4.3 Incidental Recharge

Incidental recharge is the amount of water which percolates down to the water table associated with the use of water. Incidental recharge occurs when agricultural lands are irrigated and can occur when water is applied to turf-related facilities for turf-related watering. Incidental recharge also occurs when water is released to the Santa Cruz River after being treated at the NIWWTP.

11.4.3.1 Incidental Recharge from Agricultural and Industrial Uses

Excess agricultural irrigation is a substantial source of incidental recharge. Industrial water users produce a much smaller amount. The range in agricultural and industrial incidental recharge in the Santa Cruz AMA depends on the total demand of the sector in any given year. For the agricultural sector, the Department has used an assumption that about 34 percent of the water applied to farmland is recharged to the aquifer. However, as agricultural water users increase their water use efficiency, less water will be incidentally recharged. This water quickly percolates to the water table when demand occurs in portions of the Younger Alluvium due to the shallow depth to water and the high transmissivity of the aquifer in some locations.

An incidental recharge factor of 5 percent has been assigned to all industrial water use. The Department assumes that no incidental recharge occurs as a result of municipal water use. Table 11-4 shows the range in incidental recharge factors used for the Santa Cruz AMA.

TABLE 11-4
INCIDENTAL RECHARGE ASSUMPTIONS USED FOR WATER BUDGETS
SANTA CRUZ ACTIVE MANAGEMENT AREA

Rate Applied to Source of Recharge	Source of Incidental Recharge
0%	Municipal demand
34%	Agricultural demand
5%	Industrial demand

11.4.3.2 Incidental Recharge of Effluent

Effluent discharged to the Santa Cruz River between 1992 and 1995 ranged between 14,740 and 16,721 acre-feet per year. The consulting group Camp, Dresser, & MeKee (CDM) developed a projection of the estimated reduction in inflow into sewer lines due to system improvements. Currently, cracks in the sewer lines allow water to infiltrate into the sewer system that makes its way to the NIWWTP. Based on CDM's work, the Department has estimated that a 20 percent reduction in the volume of water filtering into the sewer lines will occur due to system improvements. This calculation is described in detail in Appendix 11C.

NIWWTP effluent discharge attributable to wastewater flow from Sonora was not projected to increase beyond the level indicated in the year 2005, under the assumption that additional effluent generated would be recharged within the Los Alisos groundwater basin located exclusively within Sonora. NIWWTP effluent discharge attributable to wastewater from Arizona is projected to increase without any limitations through the year 2025. It is possible that future agreements with Mexico may allow for an increase in the volume of effluent coming from Sonora, however, such an assumption was not included in the analysis in this chapter.

11.5 RESULTS OF WATER SUPPLY AND DEMAND ANALYSES

Two water demand scenarios were developed to illustrate possible water demand conditions in the Santa Cruz AMA. Based on these calculations, if growth occurs as the ADES population projections indicate, the water demand in the AMA should increase from the current use of about 56,000 acre-feet. If water is used efficiently, projected water demand could be near 59,000 acre-feet in the year 2025. If current water use practices continue, demand in the year 2025 could be 60,000 acre-feet or more. A major factor impacting future demand will be whether riparian areas in the AMA expand, contract, or remain constant.

Table 11-5 below compares current and projected demand to the minimum and maximum supply conditions. The challenge facing the Santa Cruz AMA now and in the future will be to manage water demands and supplies such that on a long-term average basis, supplies are available to equal demands in any given year. This means that between 59,000 and 60,000 acre-feet of water supply will need to be available, on a renewable basis, to maintain safe-yield conditions through the year 2025.

In years where only minimum renewable supplies are available, the AMA's water users would need to augment nearly 21,000 acre-feet in order to maintain safe-yield conditions in that year. In years where surplus supply conditions exist, the AMA aquifers may be recharged to a significant degree, although much of the surplus supply would be moving too quickly to percolate into the aquifer and would move through the AMA and on into the Tucson and perhaps Pinal AMAs.

TABLE 11-5
DEMAND AND SUPPLY ANALYSIS
SANTA CRUZ ACTIVE MANAGEMENT AREA

	Volume of Water (acre-feet)
Demand Range	56,000 - 62,000
Minimum Supply	39,000
Maximum Supply	143,000
Safe-yield Volume	59,000 - 60,000

It is important to note that fluctuations in seasonal demands and supplies can impact water in storage and the storage capacity of local portions of the aquifer. Further analysis of the change in storage capacity on a seasonal basis would provide valuable information useful in making water management decisions in the Santa Cruz AMA.

It should also be noted that minimum supply conditions may occur in a series of years resulting in a reduction in water in storage and an increase in storage capacity. When a year of maximum or increased water supply occurs, storage capacity is filled to the degree that infiltration can occur. While dry years often occur in a series, a series of wet years does not necessarily result in considerably more recharge than a single wet year. Once the available storage capacity is filled, any more water flowing into the AMA would not recharge but would instead flow out of the AMA. Moreover, unless additional storage capacity is created, either through continued pumping during drought conditions or through physical changes to the aquifer system through augmentation efforts, the occurrence of a wet year will not necessarily result in a significant increase in the volume of water in storage. Additionally, since the rate at which high surface flow moves through the AMA is much more rapid than the rate of percolation unless the water flow that occurs in a wet year is slowed, much of the flow during a wet year will pass through the AMA without percolating into the aquifer.

11.6 ANALYSIS AND DISCUSSION

11.6.1 Safe-Yield Concepts

Safe-yield is an AMA-wide balance between water entering and leaving the aquifer on an annual basis. This includes water which is added to the hydrologic system through natural or incidental recharge and water which flows out of the system naturally and water withdrawals and uses for municipal, agricultural, and industrial purposes. Whether or not safe-yield conditions are maintained in the Santa Cruz AMA will depend on increases in demand versus augmentation measures to compensate for additional growth and seasonal and annual fluctuations in water supplies. An efficient and accurate assessment of the status of the AMA relative to safe-yield will be assisted through continued hydrologic data collection and analysis on at least a seasonal basis. More frequent data collection may provide more clues to understanding the complex hydrology of the Santa Cruz AMA.

Because the water table in the Younger Alluvium of the Santa Cruz River is strongly affected by localized water recharge and withdrawals, managing for safe-yield AMA-wide does not ensure that all subareas of the AMA will be in balance. Declines in local water table levels can result in increased pumping costs, water quality degradation and loss of the amenity of riparian vegetation and associated wildlife. If minimum supply conditions persist for very long, much of the riparian growth may suffer and possibly be lost. This would result in a decrease in the volume of riparian demand (from evapotranspiration) listed in Table 11-3. Augmentation and recharge activities may stabilize local water table levels and provide a backup supply for water users during droughts.

Not all of the excess water available during wet years will recharge the aquifer. Because wet years usually include several flood flows, much of the water moves through the AMA quicker than it can infiltrate. It is possible that only a portion of the excess flow that occurs during surplus conditions actually could recharge the aquifers, assuming that water withdrawals had created storage capacity that could be filled. Wet years occurred during the 1950s which contributed an estimated 30,000 to 40,000 acre-feet of recharge based on several extremely dry years where water withdrawals created storage capacity followed by wet conditions.

Additional water management options for the Santa Cruz AMA will be developed during the third management period. Some of these may be included as a modification of this plan. Augmentation and water distribution activities may be performed by entities such as a water district. The combination of the Department's regulatory and assistance programs and the distribution, negotiation and funding capabilities of a water district or other entity will help to ensure that water continues to be available to the AMA's water users over the long-term.

The Department has begun to develop a hydrologic model of the Santa Cruz AMA, has been involved in negotiations with Mexican officials over binational water resource issues, and has worked closely with the local community to improve the understanding of how water moves through the AMA. In addition, water right holders have become interested in resolving the many dual water rights in the AMA and in pursuing legislation to create more tools to augment, preserve, distribute, and manage water supplies in the AMA. The information contained in this chapter includes estimates of projected water conditions in the Santa Cruz AMA under current and conserving rates of demand, as well as maximum and minimum supply ranges. Although this information is not presented in a water budget due to the variability of supply both seasonally and on an annual basis, it does provide guidance toward addressing the challenge of ensuring continued availability of water to meet demands and maintaining the AMA goals into the future.

11.6.3 Variation in Conditions

Projections of future water supply conditions in the Santa Cruz AMA are subject to a number of substantial variables which could have significant impacts on the maintenance of AMA goals.

- The City of Nogales relies on groundwater pumped from the Potrero Creek aquifer and the Younger Alluvial aquifer. The long-term future of the Potrero Creek aquifer could be affected by water quality and groundwater storage conditions.

- Roughly two-thirds of the effluent generated at the NIWWTP originates in Sonora. Effluent discharged to the Santa Cruz River would be reduced if Sonora were to discontinue or reduce the volume of influent sent to the NIWWTP.

- At some point in time higher standards of effluent treatment may be required to assure good quality water is available to those utilizing the water for human consumption below the NIWWTP or in areas where treated effluent is recharged.

- It is likely that population growth within the AMA will be higher than the projections indicate. The location where the growth occurs could complicate the development of water augmentation and distribution strategies. Related to this is the question of whether additional sever and transfers will occur to support certificates or designations of assured water supply. This could affect agricultural demand as well as municipal demand.

- The variability in seasonal and annual surface water flow is another challenge to water management strategy. This will continue to be a concern upstream from the NIWWTP unless augmentation occurs in this area of the AMA.

11.7 CONCLUSIONS

Managing the Santa Cruz AMA for safe-yield is challenging due to a number of factors. First, seasonal and annual surface water flow and mountain front and tributary recharge are unpredictable and highly variable. Man-made reservoirs are either of insufficient size, are not utilized, or do not exist to a degree that would allow for an adequate backup supply during drought periods to maintain the AMA goals and provide a continuous availability for current and committed water demands. Second, effluent generated in Mexico is not a secure source of supply, and future water management activities in Nogales, Sonora could either positively or negatively affect water supplies in the Santa Cruz AMA. Third, increases in demand associated with growth may be more rapid than anticipated resulting in the need for augmentation, recharge, and other efforts to occur sooner.

The hydrologic model being developed by the Department will be an important tool to improve the understanding of the hydrologic system in the Santa Cruz AMA and evaluating the possible impacts of water demand and supply trends. Continuing data collection and analysis are likely to result in improved estimates of some of the natural water demand and supply figures contained in chapters 2, 3, and 11 of this plan.

With additional hydrologic data, funding, and cooperation with the Santa Cruz AMA community and with Mexican officials to define and implement effective water resource management options for the region, the Department will be better equipped to improve water resource management in the AMA.

APPENDIX 11A

DISAGGREGATION OF POPULATION PROJECTIONS

Benched to 1997 POPTAC projections									
Year	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**
Nogales	14398	18026	18975	20129	21079	22029	22979	23929	24879
Rio Rico	1729	3864	6737	9150	11707	14407	17305	20434	23699
Valle Verde	1680	2543	2734	2859	2984	3109	3234	3359	3484
Citizens - Tubac	798	730	858	902	932	962	992	1022	1052
Santa Cruz County small providers	1015	1183	1272	1307	1342	1377	1412	1447	1482
Provider Total	**19620**	**26346**	**30576**	**34347**	**38044**	**41884**	**45922**	**50191**	**54596**
Exempt Wells -whole AMA	370	468	560	610	660	710	760	810	860
Avg. # of New Exempt Wells/Yr 85-95	19								
Exempt Well Registrations*.75=OCC. HU	278	351	420	458	495	533	570	608	645
AMA Exempt Pop = line above*3.5ppoh	971	1229	1470	1601	1733	1864	1995	2126	2258
Nogales CCD exempt well pop.		973	1175	1084	1067	1048	1030	1012	994
SC Total (ADES Nogales CCD)		**27406**	**31548**	**35431**	**39110**	**42932**	**46952**	**51203**	**55589**
Lakewood Water Company	627	888	877	1002	1127	1252	1377	1502	1627
Pima County exempt well population		256	295	517	666	816	965	1114	1264
Pima Total		1144	1172	1519	1793	2068	2342	2616	2891
Total AMA DES		***28550***	***32721***	***36950***	***40903***	***45000***	***49294***	***53819***	***58480***

\+ Nogales grows @ 190 people per year through 2025 = growth rate 90-95.
++ Rio Rico grows @ remainder of Nogales CCD projection after exempts, smalls, Valle Verde, Tubac and Nogales come out.
+++ Valle Verde grows @ 25 people per year through 2025 = roughly growth rate average 95-96
++++ Citizens-Tubac grows @ 6 people per year from 2000 forward (avg. growth rate 85-95), and prorates 2000 projection back to 1996 service area pop.
+++++ Lakewood; 1990 and 1995 population from Annual Water Use Report, projections = 25 people every yr. (based on '85 - '95 growth)
++++++ Smalls from small provider database, minus Lakewood and Tubac through 1996, 1997 on = average growth from 95-96 (7/year).
* 1990 large provider numbers from ADWR disaggregation of 1990 Census data onto service area boundaries.
** 1985-1996 = actual data reported by large and small providers, plus wells in wells data base for exempts.
*** AMA exempts = actual # wells from ADWR database*.75 occ rate * 3.5 ppoh through 1997; proj. = 20 wells/year based on 85-95 growth / 2 (10 wells per year AMA-wide).
**** Pima exempts = DES Pima projection - Lakewood projection (from 2000 forward).
***** Nogales CCD exempts = AMA exempts - Pima exempts.

APPENDIX 11B
PROJECTED DEMAND AND EFFLUENT SUPPLIES

POPULATION	92-95 AVE	2000	2005	2010	2015	2020	2025
Nogales	18,698	20,129	21,079	22,029	22,979	23,929	24,879
Rio Rico	5,846	9,150	11,707	14,407	17,305	20,434	23,699
Valle Verde	2,643	2,859	2,984	3,109	3,234	3,359	3,484
Tubac	811	902	932	962	992	1,022	1,052
Smalls	1,252	1,307	1,342	1,377	1,412	1,447	1,482
Exempts	1,402	1,601	1,733	1,864	1,995	2,126	2,258
Lakewood	882	1,002	1,127	1,252	1,377	1,502	1,627
MEXICO	186,216	213,784	247,834	283,147	320,356		
TOTAL AMA POPULATION	31,535	36,950	40,904	45,000	49,294	53,819	58,481

GPCD - CURRENT RATE	92-95 AVE	2000	2005	2010	2015	2020	2025
Nogales	202	202	202	202	202	202	202
Rio Rico	172	172	172	172	172	172	172
Valle Verde	105	105	105	105	105	105	105
Tubac	253	253	253	253	253	253	253
Smalls	163	163	163	163	163	163	163
Exempts	188	188	188	188	188	188	188

GPCD - CONSERVING RATE	92-95 AVE	2000	2005	2010	2015	2020	2025
Nogales	202	199	196	193	192	191	191
Rio Rico	172	157	151	148	146	145	144
Valle Verde	105	121	121	121	121	121	121
Tubac	253	220	212	205	203	202	201
Smalls	163	163	163	163	163	163	163
Exempts	188	188	188	188	188	188	188

DEMAND - CURRENT RATE	92-95 AVE	2000	2005	2010	2015	2020	2025
Nogales	4,231	4,555	4,770	4,984	5,199	5,414	5,629
Rio Rico	1,126	1,763	2,256	2,776	3,334	3,937	4,566
Valle Verde	311	336	351	366	380	395	410
Tubac	230	256	264	273	281	290	298
Smalls	390	422	451	480	509	538	568
Exempts	295	337	365	393	420	448	476
TOTAL	6,583	7,668	8,456	9,271	10,124	11,022	11,946

DEMAND - CONSERVING RATE	92-95 AVE	2000	2005	2010	2015	2020	2025
Nogales	4,231	4,487	4,628	4,762	4,942	5,120	5,323
Rio Rico	1,126	1,609	1,980	2,388	2,830	3,319	3,823
Valle Verde	311	388	404	421	438	455	472
Tubac	230	222	221	221	226	231	237
Smalls	390	422	451	480	509	538	568
Exempts	295	337	365	393	420	448	476
TOTAL	6,583	7,465	8,050	8,666	9,365	10,111	10,898

APPENDIX 11B *(continued)*
PROJECTED DEMAND AND EFFLUENT SUPPLIES

DEMAND	**92-95 AVE**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**
INDUSTRIAL	1,284	1,504	1,665	1,832	2,007	2,191	2,381
AGRICULTURAL	11,339	10,339	10,339	10,339	10,339	10,339	10,339
NON-DOMESTIC EXEMPT WELLS							
Stock exempt wells	322	352	382	412	442	472	502
Exempt stock demand	161	176	191	206	221	236	251
Other exempt wells	665	825	1,097	1,897	2,697	3,497	4,297
Exempt other demand	333	413	549	949	1,349	1,749	2,149
EFFLUENT SUPPLIES:	**92-95 AVE**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**
NIWWTP Q[1](AZ) current use rate	5,019	5,472	5,773	6,074	6,375	6,676	6,977
NIWWTP Q (AZ) conserving	5,019	5,378	5,065	5,236	5,465	5,691	5,949
NIWWTP Q (SONORA)	11,169	12,692	13,603	13,600	13,600	13,600	13,600

[1] Q means the volume of effluent released from the plant.

APPENDIX 11C
EFFLUENT REDUCTION DUE TO SYSTEM IMPROVEMENTS
CITY OF NOGALES, ARIZONA
NOGALES, SONORA

I. Data Analyzed

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1990-1998
Total Use	4529	4147	4169	4218	4239	4290	4386	4482	4070	38530
GC Use	1003	591	550	415	455	529	632	755	692	5622
Total - GC	3526	3556	3619	3803	3784	3761	3754	3727	3378	32908
Sewerable Use	3526	3556	3619	3803	3784	3761	3754	3727	3378	32908
80% of Sewerable Use	2821	2845	2895	3042	3027	3009	3003	2982	2702	26326
US Influent	4448	5355	5194	5442	5170	5514	4494	4677	5617	45911
Influent/80% Sewerable	1.58	1.88	1.79	1.79	1.71	1.83	1.50	1.57	2.08	1.74

II. Nogales, Arizona Calculation

A. Assume the CDM figure of 20% reduction in water flowing into the sewer line from the surrounding water table.

1. 1990 - 1998 Average Sewerable Use = 32,908 acre-feet divided by 9 = 3656 acre-feet
2. 1990 - 1998 Average Sewerable Use x 80% = 3656 * .8 = 2925 acre-feet
3. 1990 - 1998 Average Influent = 45,911 acre-feet divided by 9 = 5101 acre-feet

4. 1990 -1998 Average volume of water inflowing into the sewer line from surrounding water table equals:

5. 5101 - 2925 = 2176 acre-feet

6. Assume a 20% reduction in 2176 acre-feet = 2176 * .80 = 1741 acre-feet remaining flow into sewer pipe after system fixes

7. Projected new ratio of influent to 80% of sewerable demand equals:
   a. 1741 + 2925 = 4666
   b. 4666 divided by 2925= 1.59

APPENDIX 11C *(continued)*
EFFLUENT REDUCTION DUE TO SYSTEM IMPROVEMENTS
CITY OF NOGALES, ARIZONA
NOGALES, SONORA

III. Nogales, Sonora Calculation

A. Influent from Mexico averages 10.0 mgd
B. Wastewater inflow is estimated to be 5.41 mgd
C. Inflow into the sewer pipe from surrounding water table is estimated to be 4.59 mgd
D. Items A-C are from CDM report, table 5.3-9 for 1996)
E. Estimated 1996 influent by Sonora = 10.0 million gallons/day * 365 days / 325,851 * 1,000,000 = 11,169 acre-feet annually
F. The estimated 1996 population of Nogales, Sonora is 186, 216 (from CDM).
G. Influent GPCD for Sonora = 11,169 / 186,216 * 325851 / 365 = 53 GPCD
H. If the inflow to the pipe is reduced by 20%, the new inflow to the pipe would equal:

4.59 mgd * .8 = 3.67 mgd

I. The improved system influent would then equal:

5.41 mgd + 3.67 mgd = 9.08 mgd

J. And the new influent from Mexico would equal:

9.08 * 365 days / 325851 * 1,000,000 = 10,147 acre-feet annually

K. And the new influent GPCD for Sonora would equal:

10,147 / 186,216 * 325851 / 365 = 49 GPCD